Cuboctostylus n. gen., a new Late Cretaceous spicule-bearing spumellarian Radiolaria from southern Sakhalin (Russia)

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ABSTRACT
A new spicule-bearing genus of Spumellaria (Radiolaria) *Cuboctostylus*, and three new species – *Cuboctostylus kasinzovae*, *C. sakhalinensis*, and *C. trifurcatus*, are described from the Late Cretaceous deposits of Sakhalin (Russia). This genus has many characters in common with the Lower-Middle Cretaceous genus *Pyloctostylus* Dumitrica, from which it differs essentially in having no pylome and the spicule centrally placed. The genus has also some characters in common with the Paleozoic family Polyentactiniidae and the Cenozoic family Orosphaeridae.

KEY WORDS
Radiolaria,
Entactinaria,
systematics,
new taxa,
Upper Cretaceous,
Sakhalin,
spicule.

RÉSUMÉ
Cuboctostylus *n. gen., genre nouveau de spumellaires à spicule initial du Cretacé supérieur, Sakhaline du Sud (Russie).*
Le nouveau genre de spumellaires (radiolaires) *Cuboctostylus* et trois nouvelles espèces – *C. kasinzovae*, *C. sakhalinensis*, *C. trifurcatus* sont décrit dans les sédiments du Crétacé supérieut, Sakhaline du Sud, Russie. Ce taxon nouveau est très proche du genre *Pyloctostylus* Dumittica du Cretacé infétieur-moyen, mais il en diffère principalement par l'absence du pylome et par la localisation du spicule dans la zone centrale. Le gente rappelle aussi les représentants de la famille paléozoïque Polyentactiniidae et de la famille cénozoïque Orosphaeridae.

MOTS CLÉS
Radiolaria,
Entactinaria,
systématique,
nouveaux taxons,
Cretacé supérieur,
Sakhaline,
spicule.

INTRODUCTION

The spicule-bearing Spumellaria are common in the Paleozoic (Foreman 1963; Nazarov 1975, 1988; Isakova & Nazarov 1986) and Triassic (Dumitrica 1978; Dumitrica *et al.* 1980; Kozur & Mostler 1981, 1982, 1994). They are well-known among the Cenozoic and Recent faunas (Hollande & Enjumet 1960; Friend & Riedel 1967). On the contrary, only few such taxa were illustrated and described from the Jurassic and Cretaceous (Dumitrica 1994; Yeh 1995). During the post-Triassic time some spicule-bearing Spumellaria survived with a low frequency. These large-sized Radiolaria can be recognized only in the case of good preservation of initial structures. Frequent spicule-bearing forms were found in the Upper Cretaceous radiolarian assemblages of the southern Sakhalin. These forms have morphological affinities with the Early-Middle Cretaceous genus *Pyloctostylus* Dumitrica, 1994 and may be descendants of this taxon. The genera *Pyloctostylus* Dumitrica and *Cuboctostylus* n. gen. have large eight-rayed spicule with long primary spines showing morphological affinity with the Paleozoic Entactinaria. Many Triassic spumellarians have small spicule without connections with primary spines (like genera *Pseudostylosphaera* Kozur & Mostler, 1981, *Sepsagon* Dumitrica, Kozur & Mostler, 1980) and cannot be ancestors of the Cretaceous taxa described herein.

GEOLOGICAL SETTING

The Upper Cretaceous key-section of the southern Sakhalin is located in the middle flow of Naiba River (Matsumoto 1938, 1954; Verecshagin *et al.* 1987) (Fig. 1). This section is represented by thin- and coarse-grained clastics with carbonate (calcilutite) concretions containing abundant ammonites, inoceramids and foraminifers. Several stratigraphic levels in the interval from the Albian to Campanian are characterized by bearing radiolarians (Kasinzova 1979, 1981; Verecshagin *et al.* 1987; Zonova *et al.* 1993).

The Cenomanian, Turonian and Coniacian deposits of the Naiba Section were studied and sampled by the author in 1992. Several radiolarian assemblages with spicule-bearing radiolarians were found. This part of section can be seen in outcrops at Shadrinka River and Naidenov Creek (west tributaries of Naiba River) (Fig. 1). The upper part of Cenomanian deposits is represented by the Naibinskaya Formation (Units 3, 4, 5) and Bykovskaya Formation (Units 1, 2). The Turonian is represented by the Bykovskaya Formation (Units 3, 4, 5 and the lower part of Unit 6), and the Coniacian is represented by the Bykovskaya Formation (upper part of Unit 6 and Unit 7).

NAIBA SECTION (Fig. 1)

Naibinskaya Formation (upper part)

Unit 3. Greenish-grey massive medium-grained sandstones with intercalations of grey siltstones. The thickness of this unit is 250-300 m.

Unit 4. (*Inoceramus tychljawajamensis* zone, lower Cenomanian-lower part of middle Cenomanian). Dark-grey massive mudstones and siltstones with small carbonate concretions with *Inoceramus tychljawajamensis* Vereschagin, 1967, *I. concentricus nipponicus* Nagao & Matsumoto, 1939, *Anagaudryceras buddha* (Forbes, 1846). The thickness of this unit is 300-450 m.

Unit 5. (*Inoceramus pennatulus-I. gradilis* zone, middle Cenomanian). Grey fine- to medium-grained sandstones and grey siltstones with rare carbonate concretions and beds of gravelites. This member is characterized by *Inoceramus pennatulus* Pergament, 1966, *I. gradilis* Pergament, 1966, *I. pressulus* Zonova, 1980. Radiolarians are represented by *Cromyomma* (?) *nodosa* Pessagno, 1976, *Hexapyramis pantanellii* Squinabol, 1903b, *Orbiculiforma maxima* Pessagno, 1976, *Amphipyndax stocki* (Campbell & Clark, 1944), *A. ellipticus* Nakaseko & Nishimura, 1981, *Dictyomitra multicostata* Zittel, 1876, *Cuboctostylus sakhalinensis* n. sp., *C. kasinzovae* n. sp. The thickness of this unit is 100-150 m.

Bykovskaya Formation (lower and middle parts)

Unit 1. (Upper Cenomanian). Alternation of light-grey fine-grained sandstones, dark-grey siltstones and black mudstones with abundant shell detritus of inoceramids and numerous car-

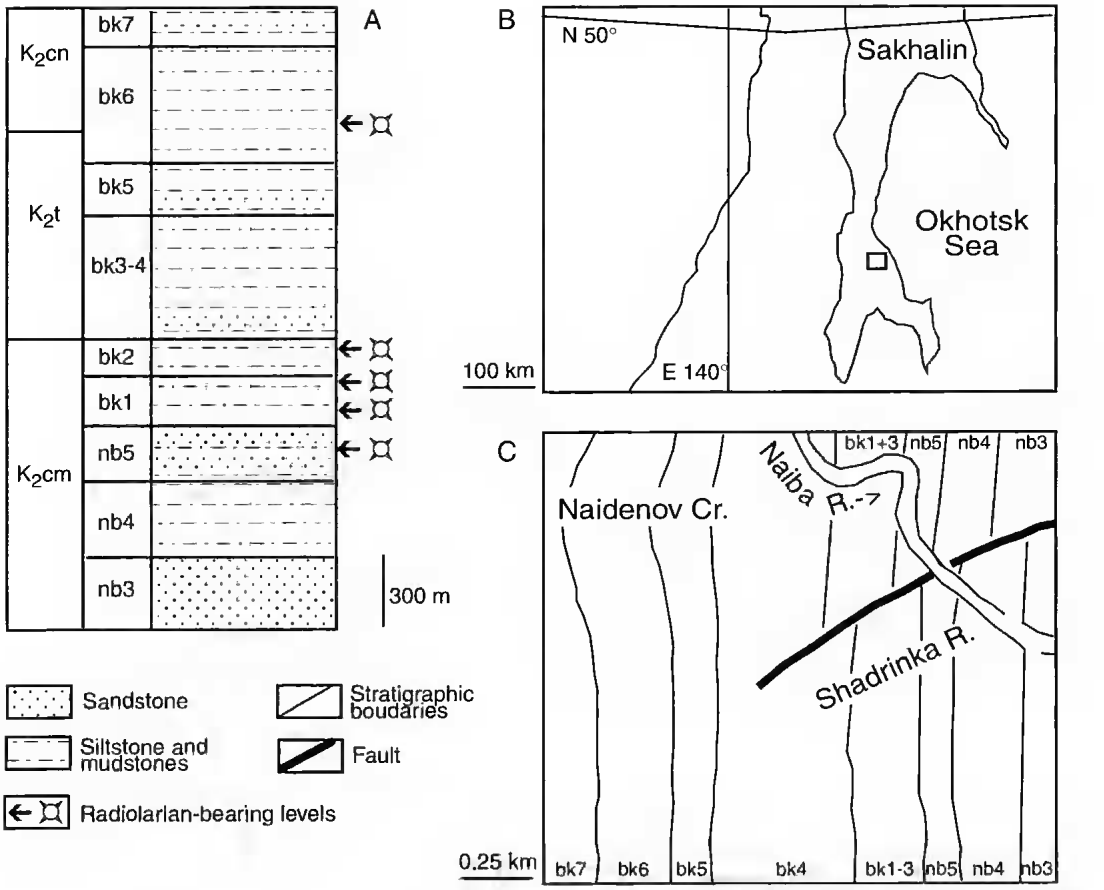

FIG. 1. — The Upper Cretaceous section at Naiba River (southern Sakhalin). **A**, stratigraphic column; **B**, geographic position; **C**, geological map of the middle flow of Naiba River; **K_2cm**, Cenomanian; **K_2t**, Turonian; **K_2cn**, Coniacian; **nb**, Naibinskaya Formation; **nb3**, third unit; **nb4**, fourth unit; **nb5**, fifth unit; **bk**, Bykovskaya Formation; **bk1**, first unit; **bk2**, second unit; **bk3**, third unit; **bk4**, fourth unit; **bk5**, fifth unit; **bk6**, sixth unit; **bk7**, seventh unit.

bonate concretions with *Inoceramus nipponicus* Nagao & Matsumoto, 1939, *I.* sp. aff. *I. tenuis* Mantell, 1822, *Gaudryceras varagurense* Kossmat, 1895 and radiolarians: *Cromyomma* (?) *nodosa* Pessagno, 1976, *Cyclastrum satoi* (Tumanda, 1989), *Dumitricaia maxwellensis* Pessagno, 1976, *Quadrigastrum insulsum* O'Dogherty, 1994, *Savaryella quadra* (Foreman, 1978a), *Phaseliforma* sp. ex gr. *P. laxa* Pessagno, 1972, *P. subcarinata* Pessagno, 1972, *Cornutella* sp., *Paronaella* sp., *Styladruppa* sp., *Amphipyndax ellipticus* Nakaseko & Nishimura, 1981, *A. stocki* (Campbell & Clark, 1944), *Archaeodictyomitra squinaboli* Pessagno, 1976, *Cassideus yoloensis* Pessagno, 1969, *Neosciadiocapsa jenkinsi* Pessagno, 1975, *Saturniforma abastrum* Pessagno, 1970, *Cuboctostylus kasiuzovae* n. sp., *C. sakhalinensis* n. sp., *C. trifurcatus* n. sp. The thickness of this unit is 140-190 m.

Unit 2. (Upper Cenomanian). Dark-grey and grey siltstones with large carbonate concretions with *Inoceramus* sp. aff. *I. tenuis* Mantell and a radiolarian assemblage similar to that in Member 1. The thickness of this unit is 70-150 m.

Unit 3. (Lower Turonian). Alternation of greenish-grey medium-grained sandstones and dark-grey siltsrones with *Inoceramus* sp. aff. *I. tenuis* Mantell. The thickness of this unit is 60 m.

Unit 4. (Turonian). Dark-grey and black siltstones and mudstones with large carbonate concretions with *Mytiloides* sp. aff. *M. labiatus*

(Schlotheim, 1813). The thickness of this unit is 450 m.

Unit 5. (*Inoceramus hobetsensis* zone, middle part of Turonian). Grey siltstones with large carbonate concretions with *Nipponites mirabilis* Matsumoto, 1954, *Inoceramus hobetsensis* Nagao & Matsumoto, 1939. The thickness of this unit is 180-200 m.

Unit 6. (*Inoceramus teshioensis* zone, upper part of upper Turonian-lower Coniacian). Dark-grey siltstones and mudstones with carbonate concretions containing *Inoceramus teshioensis* Nagao & Matsumoto, 1939, *Gaudryceras denseplicatum* (Jimbo, 1894) and radiolarians: *Archaeospongoprunum cortinaensis* Pessagno, 1971b, *Crucella* sp. ex gr. *C. plana* Pessagno, 1971a, *Histiastrum* sp. ex gr. *H. aster* Lipman, 1952, *H. latum* Lipman, 1952, *Orbiculiforma monticelloensis* Pessagno, 1971b, *Patellula minuscula* O'Dogherty, 1994, *Patulibracchium* sp. aff. *P. arbucklensis* Pessagno, 1971a, *Phaseliforma* sp. ex gr. *P. carinata* Pessagno, 1972, *Spongotripus communis* Squinabol, 1903b, *Vitorfus brustolensis* (Squinabol, 1903b), *Multastrum* sp., *Afens liriodes* Riedel & Sanfilippo, 1974, *Dictyodedalus* sp. aff. *D. acutiephalus* (Squinabol, 1904), *Xitus* sp. ex gr. *X. antelopensis* Pessagno, 1977c, *X. spicularius* (Aliev, 1965), *Cuboctostylus kasinzovae* n. sp., *C. sakhalinensis* n. sp. The thickness of this unit is 500-600 m.

Unit 7. Dark-grey siltstones and mudstones. The thickness of this unit is 100-150 m.

SYSTEMATICS

Class RADIOLARIA Muller, 1858
Order POLYCYSTINA Ehrenberg, 1838
Suborder ENTACTINARIA
Kozur & Mostler, 1982
? Family POLYENTACTINIIDAE Nazarov, 1975

Genus *Cuboctostylus* n. gen.

TYPE SPECIES. — *Cuboctostylus kasinzovae* n. sp.

SPECIES INCLUDED. — *Cuboctostylus kasinzovae* n. sp., *C. sakhalinensis* n. sp., *C. trifurcatus* n. sp.

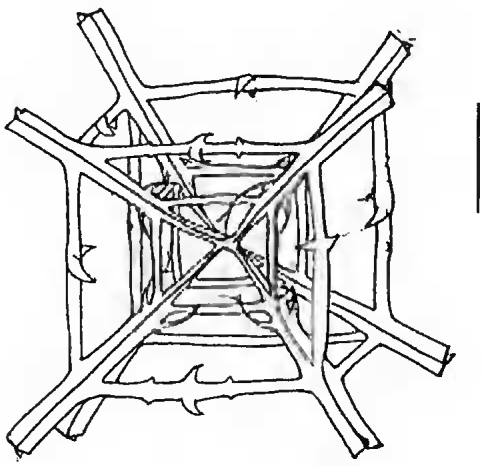

FIG. 2. — *Cuboctostylus kasinzovae* n. sp., suggested reconstruction. Scale bar: 200 µm.

ETYMOLOGY. — From the Greek *cubo* – cubic, *octo* – eight, *stylos* – spike, style.

OCCURENCE. — Cenomanian to Campanian so far as known.

DESCRIPTION

Skeleton large, with initial spicule in the center, and two or three concentric systems of cubic arches, the outermost with a subspherical latticed shell which may be missing. Spicule with a very short median bar and four spines at each end. Spines not differentiated into apical or basal. They result from successive bifurcation in horizontal and vertical planes. Spines cylindrical in the portion between MB and the innermost system of arches. They rapidly increase in width and become three-bladed outside cortical shell. Spines with two or three verticils of straight bars that unite the spines at two or three levels forming weakly developed cube-like shells. Spines aligned with the diagonal of the cube-like shells.

REMARKS

Cuboctostylus n. gen. differs from the Early to Middle Cretaceous genus *Pyloctostylus* Dumitrica by the central position of spicule and absence of pylome.

The genera *Pyloctostylus* Dumitrica and *Cuboctostylus* n. gen. undoubtedly belong to the same

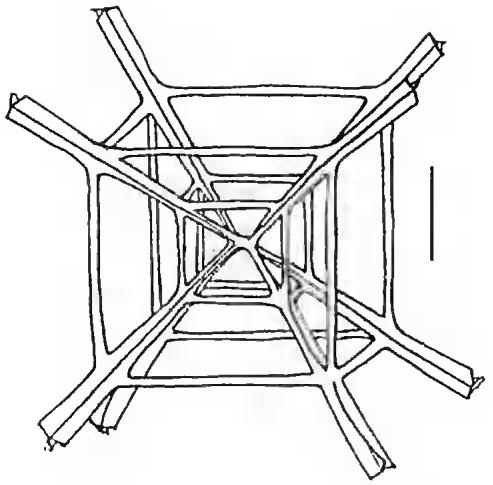

FIG. 3. — *Cuboctostylus sakhalinensis* n. sp., suggested reconstruction. Scale bar: 200 µm.

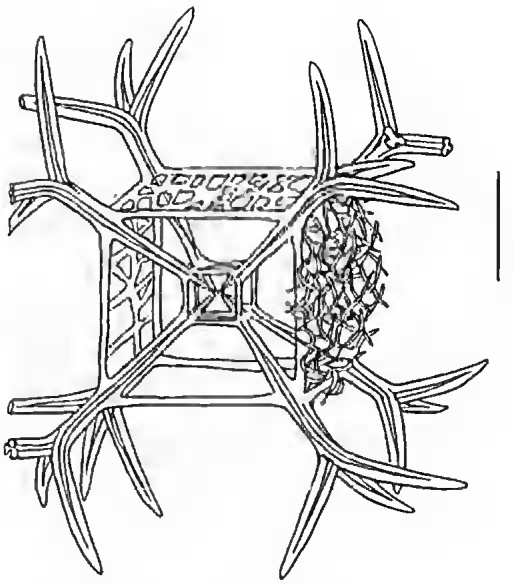

FIG. 4. — *Cuboctostylus trifurcatus* n. sp., suggested reconstruction. Scale bar: 200 µm.

phylogenetic lineage. Since *Cuboctostylus* n. gen. has no pylome it is morphologically closer to the Paleozoic genus *Polyentactinia* Foreman (Foreman 1963). Finding of this new genus shows that the spicule-bearing Spumellaria are much more frequent in the Cretaceous than was previously supposed. Dumitrica (1994) mentioned that there are many other spicule-bearing forms in the Cretaceous which are to be described.

Two Cretaceous spumellarian species – *Falsocromyodrymus ? fragosus* O'Dogherty, 1994 and *F. ? nebulosus* O'Dogherty, 1994 have some affinity with *Cuboctostylus* n. gen. (O'Dogherty 1994). Unfortunately, there is no evidence of their initial spicule and these taxa cannot be assigned now to the new genus.

Cuboctostylus kasinzovae n. sp.
(Figs 2, 5A-G, 6D, 7D-F, H)

HOLOTYPE. — GIN 4845-1, Fig. 5B, southern Sakhalin, Naiba River, Naibinskaya Formation, middle Cenomanian.

ETYMOLOGY. — The species is dedicated in honour of Ludmila I. Kasinzova, who discovered the Cretaceous Radiolaria of the Naiba sequence (south-western Sakhalin) and published their first descriptions.

OCCURRENCE. — Middle Cenomanian to Coniacian as far as known.

DIMENSIONS. — Length of the outer cube-like shell side 480-500 µm, length of the inner cube-like shell side 200-250 µm, total length of spine 900-1000 µm.

DESCRIPTION

Shell as with genus. Very short median bar with eight spines is placed in the central part of the shell. Robust outer shell and a single inner shell form two concentric cubes. Length of bars of the inner shell approximately half than of the outer shell. Spines cylindrical in the portion between MB and inner shell, beyond it three-bladed and increasing in thickness up to the outer shell. Each bar of the inner cube-like shell has one crescent-like apophyse at the corner. These apophyses form weakly developed secondary spherical level over inner shell. Each bar of the outer cube-like shell has two opposite apophyses in the middle and few short secondary spines.

REMARKS

This species differs from the species *C. trifurcatus* n. sp. by the absence of trifurcations of the distal

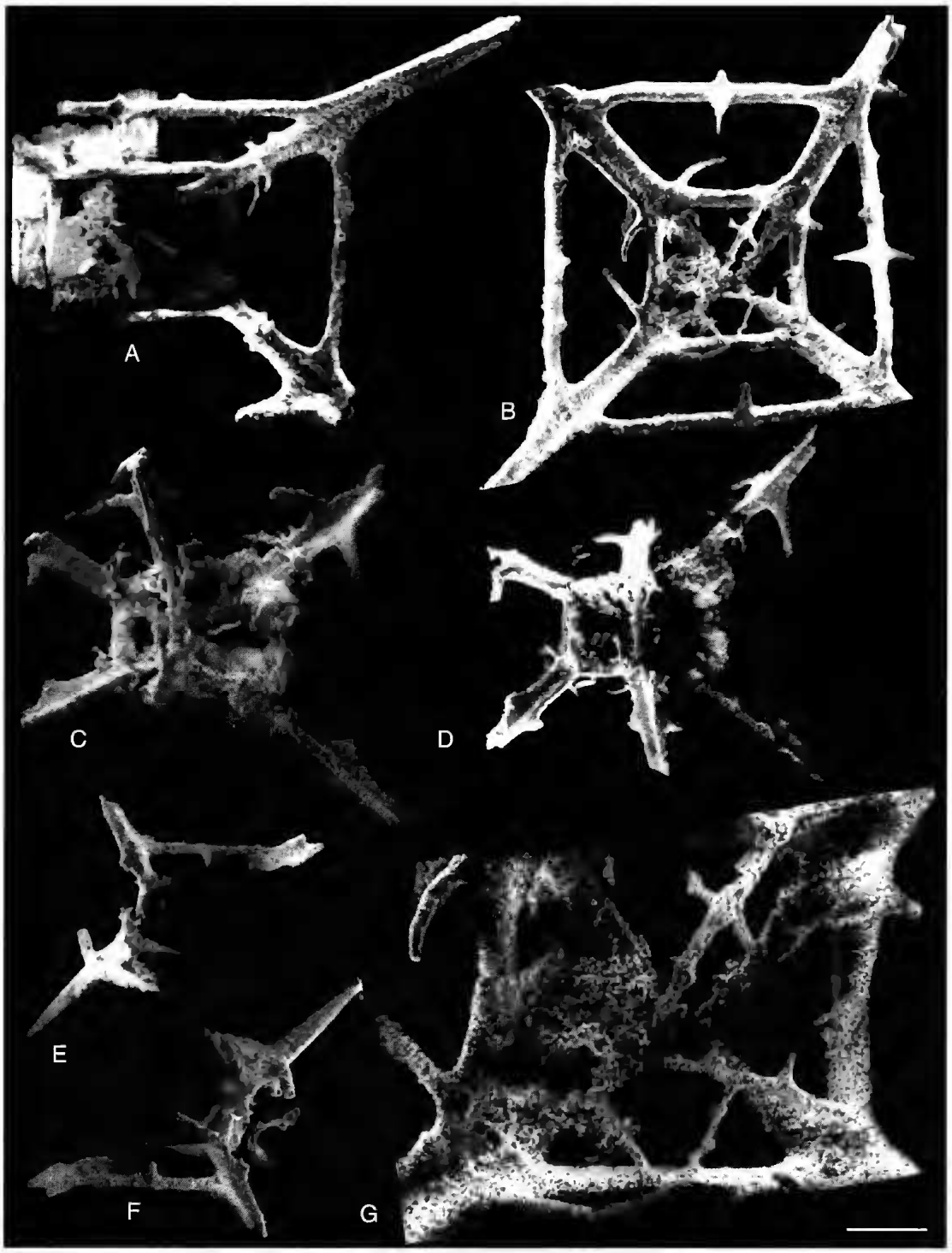

FIG. 5. — **A-G**, *Cuboctostylus kasinzovae* n. sp.; **B**, holotype, GIN 4845-1; **C**, **D**, two foreshortening on internal part of shell; **E**, **F**, fragments of shell; **G**, part of B. Scale bar: A-D, 130 µm; E, F, 200 µm; C, 300 µm.

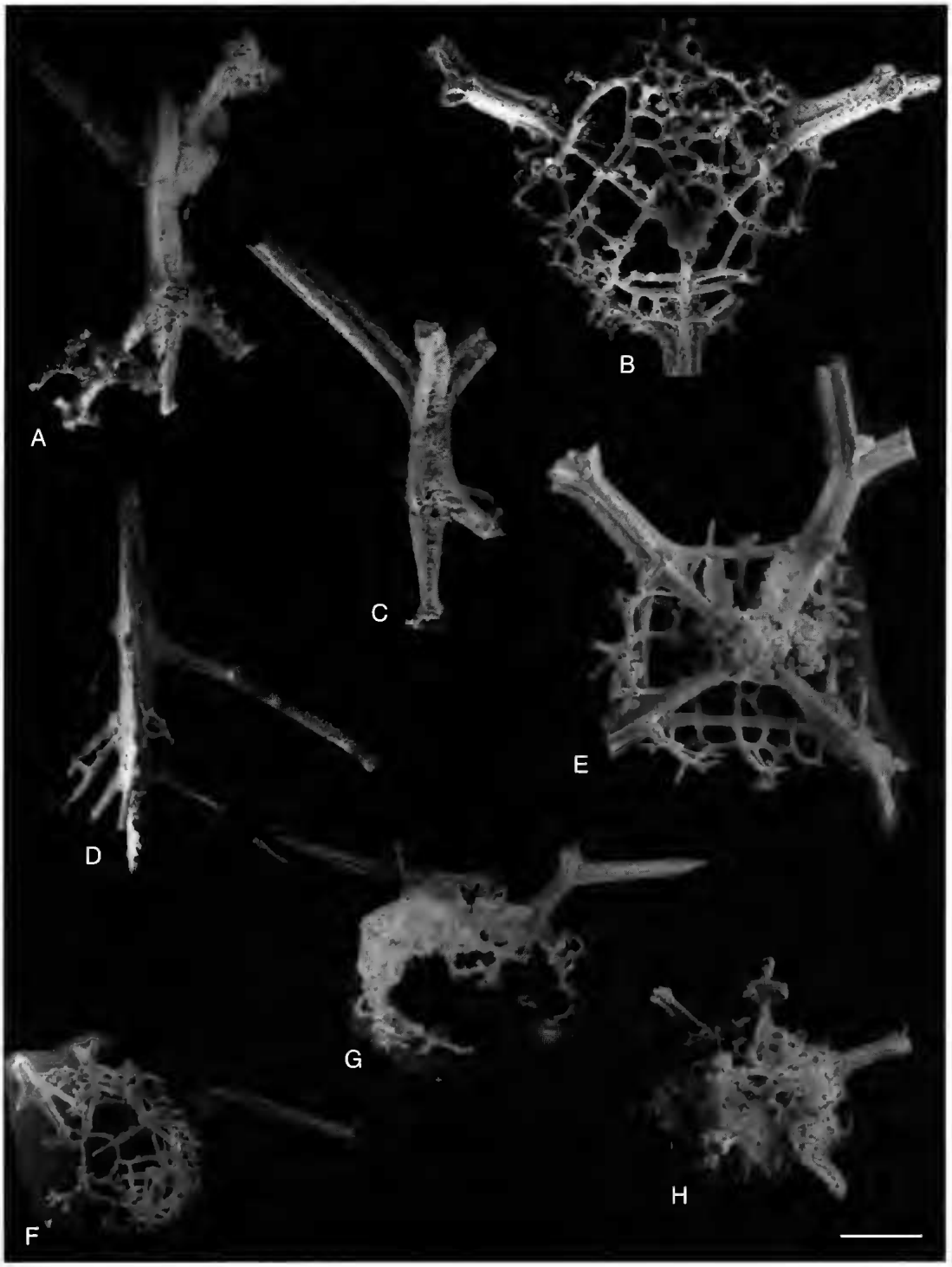

FIG. 6. — **A**, **C**, *Cuboctostylus trifurcatus* n. sp., spines; **B**, **E**, *Cuboctostylus trifurcatus* n. sp., holotype, GIN 4845-3; **B**, external view of shell; **E**, internal view of shell; both two fragments belong to one specimen; **D**, *Cuboctostylus kasinzovae* n. sp., main spine; **F**, **G**, *Cuboctostylus trifurcatus* n. sp., uncomplete shell; **H**, *Cuboctostylus trifurcatus* n. sp. Scale bar: A-E, 130 µm; F-H, 200 µm.

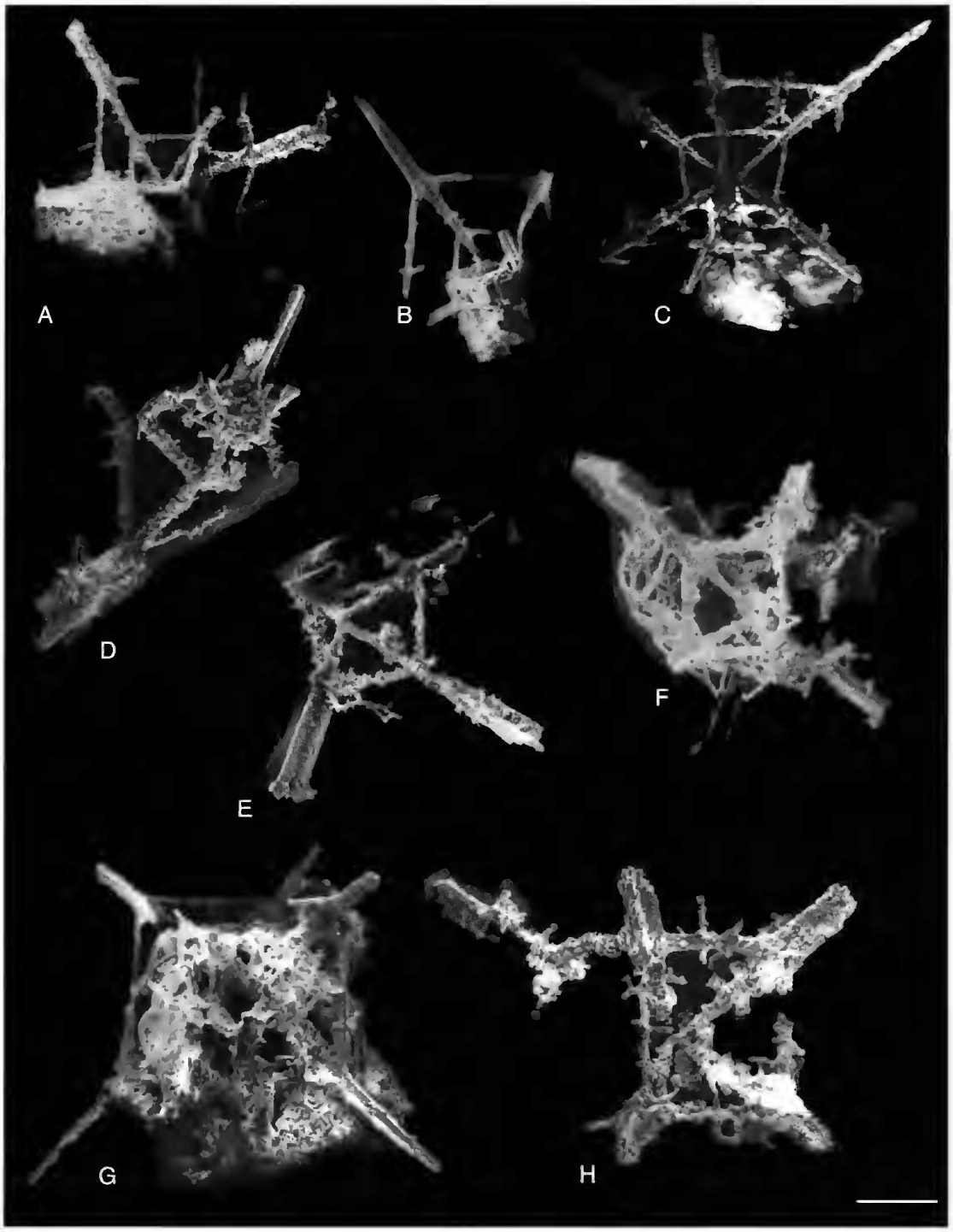

FIG. 7. — **A**, *Cuboctostylus sakhalinensis* n. sp., holotype, GIN 4845-2; **B**, **C**, *Cuboctostylus sakhalinensis* n. sp., uncomplete shell; **D**, **E**, *Cuboctostylus kasinzovae* n. sp., two fragments of one shell; **F**, *Cuboctostylus kasinzovae* n. sp., internal cube-like shell with developed apophyses; **G**, *Cuboctostylus sakhalinensis* n. sp.; **H**, *Cuboctostylus kasinzovae* n. sp., fragment of shell. Scale bar: A-C, G, 200 µm; D-F, H, 130 µm.

part of its main spines and from the species *C. sakhalinensis* n. sp. by the presence of apophyses at the outer and inner shells.

Cuboctostylus sakhalinensis n. sp.
(Figs 3, 7A-C, G)

HOLOTYPE. — GIN 4845-2, Fig. 7A, southern Sakhalin, Naiba River, Bykovskaya Formation, upper Cenomanian.

ETYMOLOGY. — From Sakhalin, eastern Russia.

OCCURRENCE. — Cenomanian to Campanian as far as known.

DIMENSIONS. — Length of the outer cube-like shell side 300-350 µm, length of the inner cube-like shell side 90-100 µm, total length of spines 600-800 µm.

DESCRIPTION
Large shell as with genus. Spines very long, simple. The outer and inner shells consist of the horizontal and vertical bars forming the edges of cube. Bars of the outer cube-like shell twice as long as those of the inner shell. Secondary spines or apophyses on these bars absent.

REMARKS
This species differs from *C. kasinzovae* n. sp. by having more delicate shells without secondary spines or apophyses. *C. sakhalinensis* n. sp. is characterized by a more exact geometrical form than the other representatives of *Cuboctostylus* n. gen.

Cuboctostylus trifurcatus n. sp.
(Figs 4, 6A-C, E-H)

HOLOTYPE. — GIN 4845-3, Fig. 6B, E, southern Sakhalin, Naiba River, Bykovskaya Formation, upper Cenomanian.

ETYMOLOGY. — From the Latin *tri* – three, *furcatus* – furcate.

OCCURRENCE. — Middle to upper Cenomanian so far as known.

DIMENSIONS. — Length of sides of the outer cube-like shell 300-350 µm, length of sides of the inner cube-like shell 80-100 µm, total length of spines 800-900 µm.

DESCRIPTION
Shell subspherical with eight very long trifurcate spines. Spicule with very short median bar is situated in the central part of the shell. Spines cylindrical in the position between MB and inner cube-like shell. They become three-bladed in the portion between inner and outer cube-like shells and rapidly increase in width. Outside the outer cube-like shell spines have a constant width. They have deep and narrow grooves and thick rounded ridges. Each spine divides into three terminations with same trefoil-like cross-section. Outer cube-like shell bars have numerous apophyses forming base of a latticed subspherical shell.

REMARKS
This species differs from *C. sakhalinensis* n. sp. and *C. kasinzovae* n. sp. by the trifurcation of spines, trefoil-like cross-section of the distal portions of main spines and by the presence of a latticed outer subspherical shell.

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